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Holocene settlement of the northern coastal plains, Northern Territory, Australia

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ABSTRACT

The northern Australian coastal plains are relatively recent landforms that have undergone dynamic evolution over the last 10,000 years. Over 300 radiocarbon dates have enabled archaeologists and geomorphologists to provide a more detailed interpretation of human settlement and resource use. This paper provides a synthesis of the archaeological evidence and integrates it within the palaeo-environmental frameworks. It characterises the timing, pattern and nature of human-environment interaction in this newly formed landscape over the last 10,000 years.

Keywords: Northern Australia, coastal plains, landforms, anthropology, archaeology, radiocarbon dates, human settlement, resource use.

INTRODUCTION

Following the post-Pleistocene marine transgression, broad plains formed along coastal northern Australia and continued to develop throughout the Holocene through processes of sedimentation and coastal progradation. They contain large tidal flats and salt pans interspersed with cheniers and are drained by substantial rivers with extensive floodplains and estuaries (Lees & Clements 1987: 312).

There has been considerable archaeological and geomorphological work undertaken on the Northern Territory coastal plains, although mostly independent of each other. The notable exceptions are joint studies on the South Alligator River (Hope *et al.* 1985; Woodroffe *et al.* 1988), the Blyth River by John Chappell and Rhys Jones (unpublished data), and the Sir Edward Pellew Group (Prebble *et al.* 2005). The geomorphological evidence demonstrates that the coastal plains of northern Australia are relatively recent formations that have undergone dynamic evolution from the mid to late Holocene. Studies have been carried out on the Victoria and Daly Rivers in the west, Darwin Harbour, the Adelaide, Mary and South Alligator Rivers, Magela Creek, Blyth River, and Groote Eylandt and the Edward Pellew islands in the east (Fig. 1). The evolutionary sequence of the coastal plains was similar right across the Northern Territory, the differences being caused by topography and timing.

How did humans respond to these newly created landscapes? This question has been addressed by an extensive body of research over the past 40 years focused on the archaeology of the Northern Territory coastal plains. The early research effort was concentrated mainly in the Alligator Rivers region of what is today Kakadu National Park (Kamminga & Allen 1973; Schrire 1982; Jones 1985; Allen & Barton 1989), but the last 15 years has seen many other regions investigated. As a result of this research, many more radiocarbon dates have become available, providing an emerging pattern of Holocene settlement across the coastal plains of the Top End as a whole. This paper presents a synthesis of these new data to provide an overview of the chronology of occupation and the changing nature of the archaeological record, which includes several different site types – rockshelters, shell mounds, shell middens, earth mounds, artefact concentrations and contact sites.

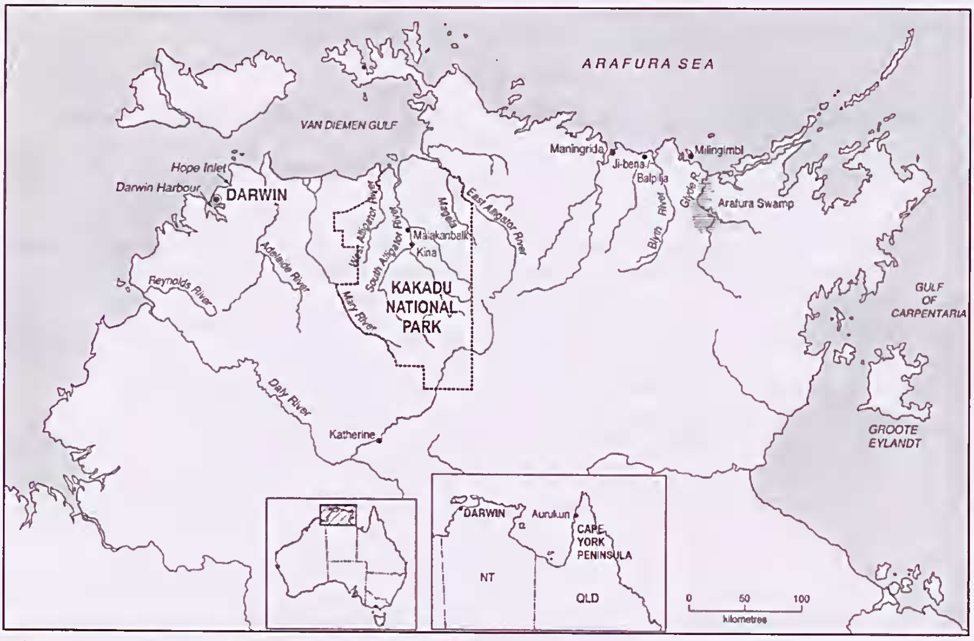

Fig. 1. Location map, showing the Top End of the Northern Territory.

In addition, information about palaeoclimates and the geomorphological evolution of the northern coastal plains is summarised to provide the environmental framework for the archaeological data. Visibility plays a major role in site location. Archaeological sites are difficult to observe in some coastal environments such as laterite plains and swampy areas. During the marine transgression, former shorelines and associated archaeological evidence were submerged (Woodroffe *et al.* 1988). As well, the extensive nature of mangrove cover during the Big Swamp phase may have almost completely removed evidence of occupation, most of which for this period is found in rockshelters. Open sites proliferated after sea level stabilisation approx. 6000 years ago, which is almost certainly a function of improved visibility.

PALAEOCLIMATE

It is widely acknowledged that there has been an increase in climatic variability in the Australasian region in the last few thousand years, in particular from approximately 1000 BP to the present (Kershaw 1983; Wasson 1986; Gagan *et al.* 1994; Kershaw 1995; Shulmeister 1999:82; Gagan & Chappell 2000; Prebble *et al.* 2005; Wasson & Bayliss 2010; Williams *et al.* 2010). Many of the longer-term trends in climate change that have occurred during the period spanning the mid Holocene to the present day are related to the El Niño/Southern Oscillation (ENSO) cycle, which has strongly influenced climatic patterns in Australia (McGlone *et al.* 1992; Shulmeister & Lees 1992; Jones *et al.* 1999; Shulmeister 1999; Gagan *et al.* 2004; Turney & Hobbs 2006), and at present represents the principal source of inter-annual climatic variability within the Indo-Pacific region (Glantz 1991; Diaz & Markgraf 1992; Allan *et al.* 1996; Rowland 1999) (Fig. 2).

The pattern of climatic shifts portrayed in recent reviews of the climate history of the South Pacific region indicates a change from low seasonality in the early Holocene to increased seasonality in the late Holocene (Markgraf *et al.* 1992; Shulmeister 1999). There also appears to be a general trend toward increased aridity in the mid to late Holocene, as supported by data extracted from coral, foraminifera, and varve, lake and sea bottom sediments from sites in Australia and the circum-Pacific region (McPhail & Hope 1985; Brookfield & Allan 1989; Singh & Luly 1991; McGlone *et al.* 1992; Hope & Golson 1995; Kershaw 1995; Nott *et al.* 1999; Rodbell *et al.* 1999; McCarthy & Head 2001; Kim *et al.* 2002; Koutavas *et al.* 2002). Evidence from pollen records on Groote Eylandt are also indicative of this environmental change from continuously increasing rainfall (effective precipitation) during the early Holocene, to a period of reduced rainfall and increased climatic variability after 4000 BP (Shulmeister & Lees 1995). In the Groote Eylandt archipelago, effective precipitation declined sharply soon after 3700 BP, with evidence across Australia indicating that climate became more variable after this time (Shulmeister & Lees 1995). Geomorphic data from cheniers and coastal dunefields (Lees & Clements 1987; Lees *et al.* 1990; Lees 1992; Lees *et al.* 1992) indicate that some of the observed changes in these systems were synchronous across northern Australia, and may represent coherent, broad-scale climatic signals (Shulmeister 1999; Prebble *et al.* 2005) (Fig. 2).

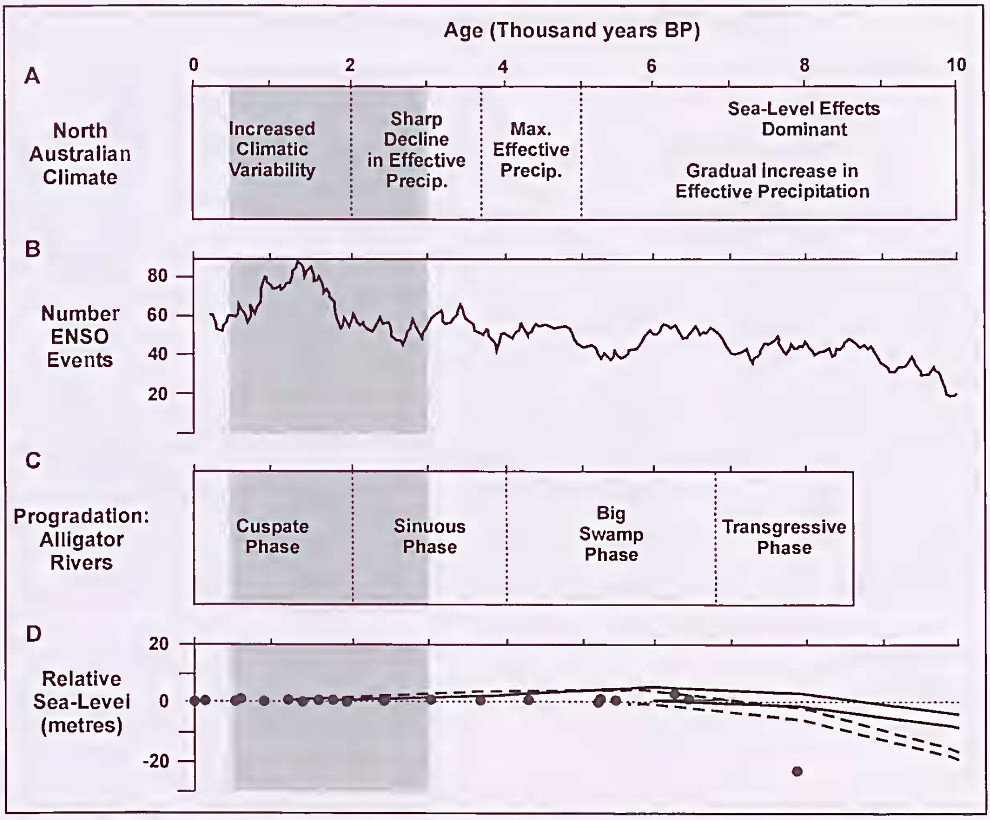

Fig. 2. North Australian Holocene environmental and climatic phases (grey shading indicates main mounding period).

LANDSCAPE

The dated archaeological sites are located roughly in five regions – (1) the West Coast represented by the Reynolds River (Guse & Majar 2000; Guse 2005); (2) the Darwin Region, including Darwin Harbour, Hope Inlet (Hiscock 1997; Bourke 2000; Hiscock & Hughes 2001; Crassweller 2002; Bourke 2004, 2005a, 2005b; Bourke & Crassweller 2006; Crassweller 2006;); the Adelaide River (Smith 1995; Crassweller 1996; Brockwell 2001, 2006a, 2009) and Mary River (Baker 1981; Guse 1992); (3) western Arnhem Land, including the Alligator Rivers and Magela Creek (Schrire 1982; Meehan *et al.* 1985; Woodroffe *et al.* 1988; Allen & Barton 1989; Roberts *et al.* 1990; Mowat 1995; Roberts *et al.* 1998), Bald Rock and Malarrak in the Wellington Ranges (May *et al.* 2010) and the Cobourg Peninsula (Mitchell 1994a, 1994b, 1996); (4) central Arnhem Land represented by the Blyth River and Milingimbi (McCarthy & Setzler 1960; Mulvaney 1975; Meehan 1982, 1988, 1991; Roberts 1991, 1994; Brockwell *et al.* 2005); and (5) eastern Arnhem Land along the east coast of the Gulf of Carpentaria, including Cape Arnhem (Bourke 2001); Port Bradshaw (Schrire 1972), Blue Mud Bay (Faulkner & Clarke 2004; Faulkner 2006, 2008, 2009; Faulkner & Clarke 2009), Groote Eylandt (Clarke 1994; 2000a, 2000b; Clarke & Frederick 2006; 2008, 2011) and the Edward Pellew islands (Sim 2002; Prebble *et al.* 2005; Sim 2005; Sim & Wallis 2008) (Fig. 1).

The landscape covered by the study areas is diverse and includes: dissected sandstone and lateritic plateaux bordering the coastal plains; large rivers and creeks; immense floodplains containing vast freshwater wetlands; and saline mudflats further towards the coast. Mangrove forests fringe coastal cheniers and tidal mudflats, headlands protrude onto coastal salt flats, mixed woodland dominates on slopes and plains. There are large stretches of open mixed woodland, broad sandy beaches and extensive dune fields, pockets of monsoon rainforest, and grassland, broad sandy beaches, shallow bays and off-shore islands, some substantial in size that can sustain permanent human populations.

ARCHAEOLOGY AND CHRONOLOGY

This complex landscape is reflected in the archaeology, which consists of numerous occupied rockshelters dating back to the Pleistocene (Kamminga & Allen 1973; Schrire 1982; Jones & Johnson, 1985a, 1985b; Allen & Barton 1989, Roberts *et al.* 1990, 1998), thousands of panels of magnificent rock art in the escarpment and outliers on

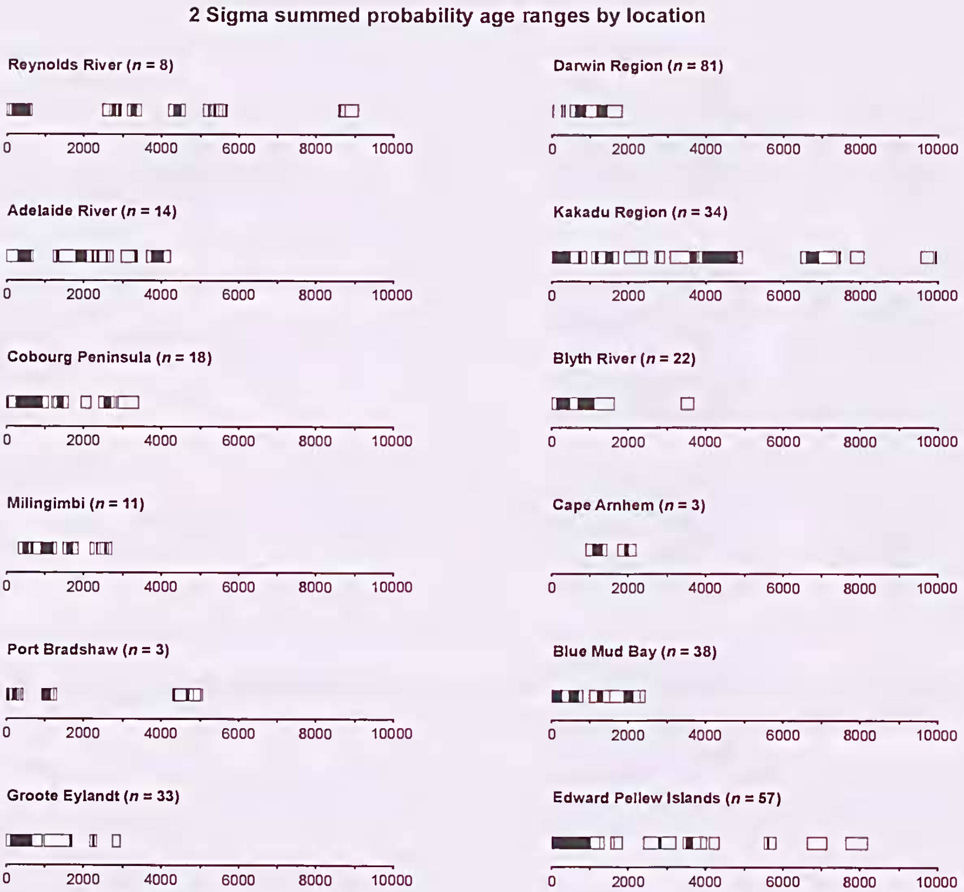

Fig. 3. C14 graphs by location.

the coastal plains (Chaloupka 1985; Lewis 1988; Taçon 1989; Chaloupka 1993; Taçon 1993; Taçon & Chippindale 1994; Taçon & Brockwell 1995; Taçon *et al.* 1996; Guse & Woolfe 2006; May *et al.* 2010; Taçon *et al.* 2010; Wesley in press), clusters of earth mounds and extensive artefact concentrations along the floodplain margins (Baker 1981; Smith 1981; Meehan *et al.* 1985; Brockwell 1989; Guse 1992, Hiscock *et al.* 1992; Brockwell 1996; Hiscock 1996; Guse & Majar 2000; Brockwell 2001, 2005; Guse 2005; Brockwell 2006a, 2006b, 2009), and middens and shell mounds on the lower floodplains and along the coast (McCarthy & Setzler 1960; Mulvaney 1975; Meehan 1982; Woodroffe *et al.* 1988; Hiscock & Mowat 1993; Clarke 1994; Roberts 1994; Mowat 1995; Hiscock 1997; Bourke 2000, 2001, 2004; Faulkner & Clarke 1994; Bourke 2005b; Brockwell *et al.* 2005; Bourke & Crassweller 2006; Faulkner 2006, 2008; Sim & Wallis 2008; Faulkner 2009).

Dates have been calibrated in order to ensure a robust comparison of the conventional radiocarbon ages from different regions and the different site types. Over 300 radiocarbon dates are now available. Details of calibration methods and a tabulated list of dated sites can be found in Brockwell *et al.* (2009). Evidence from rockshelters suggests that Aboriginal people began to occupy and use the resources of the coastal plains at the time of their formation over 10,000 years ago, but the majority of sites are 4000 years or younger. Fig. 3 illustrates chronology by location. On the basis of the environmental evidence, the archaeology can be divided into five temporal periods:

10,000–6000 BP. Evidence of occupation on the coastal plains has been dated from the early to mid Holocene period, encompassing the time of rising sea levels and the 'Big Swamp Phase'. Effective precipitation and temperature were gradually increasing during this phase. During the post-Pleistocene transgressive phase, the down-cut river valleys of northern Australia were drowned. The various river systems responded differently to this event. Some, like Darwin Harbour, became deep-water embayments. Others, through processes of sedimentation, formed vast mangrove swamps. This has been described as the 'Big Swamp Phase' and dates from about 7000 BP to approx. 4000 BP (Woodroffe *et al.* 1985, 1986; Chappell 1988; Woodroffe 1988; Woodroffe & Mulrennan 1993) (Fig. 4).

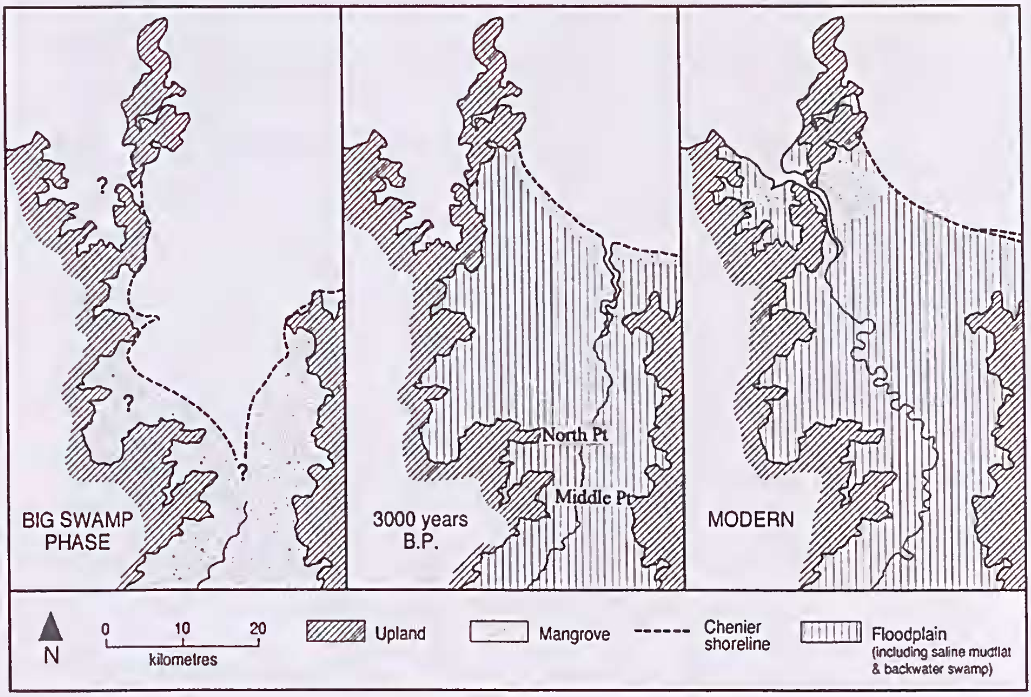

Fig. 4. Developmental phases of the northern river floodplains.

Allen (1996: 198, 201; Allen & Barton 1989: 104) made the point that the mangrove forests of the Big Swamp Phase would have presented a formidable barrier to movement and settlement. Access to the river channels and the coastal plains may have been impossibly difficult. The distribution of sites during the Big Swamp Phase in western Arnhem Land reflects this situation and is consistent with Allen and Barton's prediction that "Seasonal movement and sites would have been restricted to the plateau valleys, the plateau margins, and the lowland corridors between the tidal floodplains" (Allen & Barton 1989: 104).

This period is represented by cultural sequences mainly from rockshelters and two middens. In the west, Djagorda 2 shelter on the Reynolds River contained a low density of stone artefacts (Guse 2005: 113). At the edge of floodplains in sub-coastal western Arnhem Land, the lower levels of Nawamoyn and Ngarradj Warde Djobkeng shelters in the Alligator Rivers region were dominated by estuarine shellfish soon after the establishment of the vast mangroves of the Big Swamp Phase approx. 7000 BP (Kamminga & Allen 1973: 45–47; Schrire 1982: 85–97, 118–30; Allen & Barton 1989: 89). At Nawamoyn and Malakunanja II fragments of mammals (open woodland), fish (unidentified) and reptiles (woodland) occurred throughout the midden levels, as did stone artefacts and bone tools (mostly spatulate points at Nawamoyn). There were human burials in Nawamoyn and Malakunanja II. Malarrak and Bald Rock in the Wellington Ranges were first occupied in the Pleistocene and appear to have been occupied throughout the Holocene (May *et al.* 2010). Although not dated, the base of the deposit at Borngolo Shelter in eastern Arnhem Land contains marine fauna, which Schrire (1972: 662) surmises is consistent with occupation after sea level stabilisation 6000 –7000 years ago. Also in eastern Arnhem Land, the lower levels of Mushroom Rock (VB17) and Wobuya Shelter (WS) on Vanderlin Island in the Edward Pellew islands contain stone artefacts and the remains of shellfish from mangroves and open mudflats (Sim & Wallis 2008: 102) (Fig. 5). During this period, the Edward Pellew islands were still attached to the mainland. Following the post-glacial marine transgression, the islands appear to have been abandoned approx. 6700 years BP and not reoccupied until 4200 years ago (Sim & Wallis 2008: 102).

In western Arnhem Land, one date was taken from a midden (Kapalga P) buried on the lower South Alligator River floodplains, which is dominated by the mangrove shellfish *Telescopium telescopium*. The substrate contains mangrove wood from the Big Swamp Phase (Woodroffe *et al.* 1988: 97). Muyu-ajirrapa midden on the Blyth River in central Arnhem Land was also dated to this period. However, there may be a problem with this charcoal date, as its shell pair was much younger. The midden is dominated by *Dosinia* sp., an open beach species that proliferates in sandy mud flats.

Although direct correlation of art styles, climatic phases and Aboriginal settlement is problematic, it has been argued that the pattern of settlement and economic organisation described above is reflected in the rock art, and can suggest

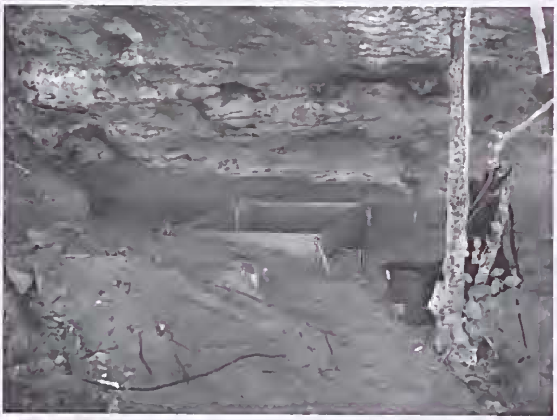

Fig. 5. Vanderlin Island rockshelter. Photograph: Robin Sim.

insight into the underlying social systems. However, it must be pointed out that these conclusions are highly interpretive and are not closely tied to the radiocarbon chronology. For example, it is argued for western Arnhem Land that the so-called 'Dynamic Figures' depicted in hunting scenes with macropods and other terrestrial fauna are associated with the arid, inland environment that existed approx. 10,000 years BP (Chaloupka 1993; Chippindale & Taçon 1998) (Fig. 6). The mostly male figures wear elaborate head dresses, pubic fringes and bustles. They use weapons that include single pronged spears, boomerangs and hafted axes, and carry dilly bags (Chaloupka 1993: 106–110; Taçon & Chippindale 1994; Taçon & Brockwell 1995: 684). The head dresses and bustles have been compared with those commonly found today in Papua New Guinea and West Papua, and may refer to a time when the land formed one continent with Australia (Chaloupka 1993: 110). Taçon (1994: 113) argues that the rate of art production varied over time and that this period is one of the periods when rock art was produced prolifically. The rock art of this period is also regionally consistent between central and western Arnhem Land, which implies cultural uniformity over a wide area (Taçon 1993: 118). Layton (quoted in Taçon & Chippindale 1994: 216, 225) suggests that this is the result of environmental conditions that required collective hunting strategies to capture large terrestrial fauna. The implied later art of this period, the so-called 'Post-Dynamic Figures' (Chaloupka 1985; Chippindale & Taçon 1998: 107) are shown in more static poses and their relationship to the Dynamic Figures is not known.

6000-4000 BP. The period 6000–4000 BP encompassed sea level stablilisation and the decline of the 'Big Swamp Phase'. Following the cessation of sea-level rise approx. 6000 BP, sedimentation and coastal progradation resulted in vertical accretion of the floodplains, and caused the development of extensive coastal plains. Effective precipitation and temperature continued to increase until approximately 5000 BP. With the decline of tidal influence, mangroves retreated seawards and towards the banks of the rivers and had mainly disappeared from the floodplains by 4000 years BP (Woodroffe *et al.* 1988: 98; Woodroffe & Mulrennan 1993) (Fig. 4).

There are dates from rockshelters, shell mounds and earth mounds during this period. On the Reynolds River, three Tabletop Range rockshelters, Djagorda 2 and Walker Creek 6, were excavated. Although only Majar was dated to this period, dates and rates of deposition from these sites imply an increasing site usage in the region after 4500 BP. There was also a large increase of stone artefacts deposited at Majar approximately 4000 years ago (Guse 2005: 97).

In western Arnhem Land, there is a marked decrease in the mangrove-associated shellfish *Polymesoda erosa* and *Telescopium telescopium* and an increase in *Cerithidea* sp. [probably *C. anticipata*] between the lower and upper midden levels at Malangangerr and Nawamoyn (Schrire 1982: 88–89, 120–22, 233–34; Hiscock 1999: 94–95), linking these sites to the decline of the Big Swamp Phase. *Telescopium telescopium* prefers a *Rhizophora* mangrove habitat, which dominated in the Big Swamp Phase. Similarly, *Polymesoda erosa* is likely to be more abundant in *Rhizophora* forests where it is found along small streams. *Cerithidea* sp. can be gathered in large numbers from the trunks of *Avicennia* and *Bruguiera* mangrove trees, which survive in drier conditions, and replaced *Rhizophora* at the end of the Big Swamp Phase in archaeological sites in western Arnhem Land (Hiscock 1999: 95–96). Malangangerr and Nawamoyn contain many bone tools, with an increase in bipoints in the upper midden levels (Schrire 1982: 85–97). Based on ethnographic evidence, which associates bone uni and bipoints with multi-pronged spears used for fishing in western Arnhem Land, Schrire (1982: 63, 95, 249) speculates that this pattern indicated a shift from exploitation of mangrove/mudflat shellfish to a greater reliance on fishing towards the end of this period.

Malakunanja II contains a similar range of fauna to Malangangerr. It also contains burials (Kamminga & Allen 1973: 45–46). Allen & Barton (1989: 90) argue that the dating of the top spit of Malakununja II to the latter part of this period indicates that this site was mostly abandoned coincident with the retreat of the mangroves. Unifacial and bifacial stone points first appeared in the sands below the midden at Ngarradj between 4862 – 3837 cal. BP (Allen & Barton 1989: 93). As Allen and Barton said of the rockshelters in western Arnhem Land, "The fact that every date that can be reliably associated with the mangrove/mudflat shell middens at these sites falls between 3000 and 7000 years BP suggests a high degree of correlation between the archaeological record and the geomorphological evidence for the local occurrence of mangroves" (1989: 90).

In eastern Arnhem Land the lower level at Borngolo, the top of which is dated to this period, contains stone and bone tools, and a wide variety of fauna that reflects exploitation of the open sea (dugong and fish), sandy shore (turtles and turtle eggs), rocky shore (oysters, fish, crabs), mudflats (estuarine shellfish) and land (mammals, reptiles, echidnas,

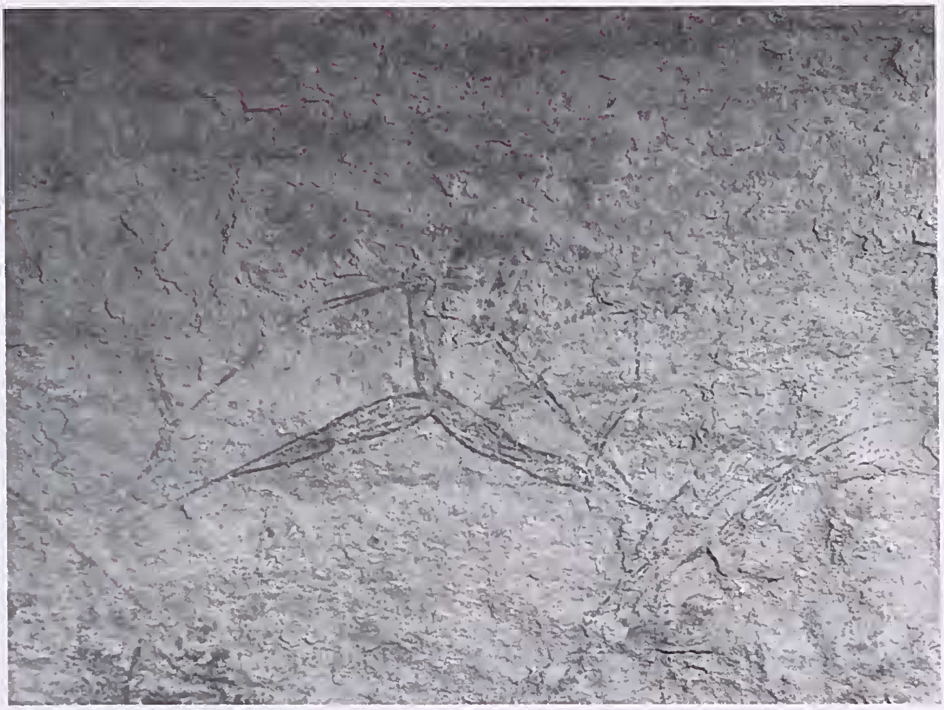

Fig. 6. Dynamic figure. Photograph: Daryl Wesley.

birds) (Schrire 1972: 662, 665). There is no evidence for occupation during this period at Vanderlin Island in the Edward Pellew islands, which appears to have been abandoned just before it was truncated from the mainland by rising sea levels (Sim & Wallis 2008: 102).

Anadara-dominated shell mounds begin to appear during this period in the west at Werat 1 on chenier ridges of the coastal plains of Reynolds River (Guse 2005: 114), and on Field Island 1 and 2 in western Arnhem Land (Hiscock & Mowat 1993; Mowat 1995: 154–55). This pattern reflects exploitation of beach species from open sandy mud flats, the preferred habitat of *Anadara granosa*. On the West Alligator River some undated shell mounds were dominated by *Anadara granosa*, and others by open beach species such as *Marcia hiantina* and *Circe* sp., which suggests that the occupants were exploiting open mud and sandy beaches extant in the mid-Holocene (Mowat 1995: 154–55). Variability in species composition between these mounds is linked to the formation of mounds at different times and reflects changing environmental conditions along the coast in the mid to late Holocene (Mowat 1995: 154, 163). Mowat (1995: 163) concludes that the coastal areas were not abandoned as conditions changed, but rather the inhabitants adapted their foraging strategies accordingly. Hiscock (1999: 96) observes that the existence of shell mounds from different regions indicates widespread foraging along the coast at this time.

The base of earth mound HD1 on the now sub-coastal portion of the Adelaide River floodplains contains estuarine shell associated with the Big Swamp Phase (Brockwell 2006a); and while data about shell species were not collected, Woodroffe *et al.* (1988: 97) record grindstones, hammerstones and manuports from the surface mound Kapalga H2 on the black soil plains of the lower South Alligator River in western Arnhem Land, which elsewhere has been classified as an earth mound (Brockwell 2006b).

At Point Stuart on the mouth of the Mary River, Baker (1981: 79) infers a date of 4500 years BP for a midden located on a chenier ridge on the basis of geomorphological investigations. In the lower levels *Telescopium telescopium* and *Crassostrea* sp. dominate the midden. These estuarine species inhabit stands of *Rhizophora* mangoves, which were extant on the floodplains during the Big Swamp Phase.

Rock art during this period, such as 'Simple Figures with boomerangs' and 'Yam Style Figures' (Chaloupka 1985), shows increasing diversity and regionalisation (Taçon 1993: 114; Taçon & Chippindale 1994: 217). Early X-ray art also appears. It shows simple internal features and is dated to a minimum age of 4000 years BP, based on radiocarbon dating of beeswax from a rockshelter in western Arnhem Land (Nelson *et al.* 1995; Watchman & Jones 2002). A greater diversity of animal species is depicted, including those from the estuarine floodplains of the Big Swamp, such as barramundi (*Lates calcarifer*), catfish (*Arius* sp.) and estuarine crocodile (*Crocodylus porosus*) (Chaloupka 1985: 277; Lewis 1988: 50–55; Chaloupka 1993: 162; Taçon 1993; Taçon & Chippindale 1994: 217; Chippindale & Taçon 1998: 107). There are changes in material culture too. Boomerangs, associated with hunting large animals on open plains, disappear and new weapons make their appearance, including spear-throwers, spears with hafted spear points and three-pronged spears associated with fishing (Chaloupka 1985: 277; Lewis 1988: 55, 96; Chaloupka 1993: 146; Taçon & Chippindale 1994: 224; Chippindale & Taçon 1998; Brockwell & Akerman 2007).

It is suggested that large battle scenes depicted in the art of this period may reflect more tightly organised societies in conflict over access to resource bases (Taçon & Chippindale 1994: 224–225). Lewis (1988: 90) suggested that conflict might have been created by the drowning of coastal land by rising seas and forced migration inland onto other territorial land, although there is no direct evidence for this. It is also suggested by some authors that the Yam Figures might be associated with rising seas (Chaloupka 1985; Lewis 1988; Chaloupka 1993: 138–145; Taçon & Chippindale 1994; Taçon *et al.* 1996). Chaloupka (1985: 276) argued that yams need over 120 cm of rainfall to thrive and may have been an important staple replacing grass seeds in the preceding drier period. He also comments that the break from both previous and subsequent styles was such that it implies major ideological and cultural shifts (1993: 143). Likewise, Taçon *et al.* (1996) argue that the appearance of the Rainbow Serpent motif, a hugely important feature of current mythology, was associated with increased rainfall and sea-level rise in the mid-Holocene. Taçon & Brockwell (1995: 25) point out that land lost to rising water was probably observable in a lifetime. Taçon *et al.* (1996: 117) argue that "Ultimately, the most unusual aspects of change – snakes slithering away from drowning landscapes, rainbows overhead and strange 'new' creatures such as pipefish washed ashore – were combined into a powerful metaphor and symbol of change itself." Lewis (1988: 91) suggests that the Rainbow Snake, which became a common image in many different accessible locations at or near campsites in this period, acted as a unifying symbol in times of change. Drawing an association between the mid-Holocene establishment of the monsoon pattern of rain and rock art, Chaloupka (1985: 277) speculates that the Lightning Man (*Namarrgon*) may have appeared in the art at this time.

4000-2000 BP. Sites dated to 4000–2000 BP encompass a Transition Phase between estuarine conditions and the beginnings of the Freshwater Phase on the floodplains of the north. Higher effective precipitation continued into this period until approximately 3700 BP, followed by increasing patterns of aridity. The rivers underwent a so-called 'Sinuous Phase', which describes their meandering nature across the coastal plains. The following 'Cuspate Phase' of river development refers to the formation of wide reaches and pointed bends, which occurred after 2500 years ago. Continued sedimentation and the slowing of coastal progradation during this phase led to a cut-off of the tidal influence. Palaeochannels were created and the floodplains contained a mosaic of estuarine, freshwater and mudflat areas (Woodroffe *et al.* 1986; Chappell 1988; Woodroffe 1988; Woodroffe & Mulrennan 1993) (Fig. 4).

Increasing numbers of shell mounds, earth mounds and middens fall within this time period. Initial observations suggest established settlement patterns developed in the Reynolds River area after 4000 BP. Another indicator is perhaps the uniformity of the artefact assemblages across the different environmental zones after 4000 BP (Guse 2005: 112). In western Arnhem Land, Allen & Barton (1989: 90–91) concluded that all four rockshelter sites, Malakunanja II, Malangangerr, Nawamoyn and Ngarradj Warde Jobkeng, were mostly abandoned by the end of the Transition Phase and only sporadically occupied afterwards. However, Hiscock (1999: 96) argued that the timing for this model of abandonment may be too rigid and that at the rockshelter of Paribari accumulation of midden deposit continued for sometime afterwards. The existence of an intermediate saline mudflat phase in the development of the floodplain is consistent with and confirmed by the compositional changes in the middens in the nearby archaeological sites. At Malangangerr, Nawamoyn and Paribari, there is a shift over time from exploitation of the bivalve species *Polymesoda erosa* in the lower midden levels to the mud whelk *Cerithidea* sp. in the upper levels (Schrire 1982: 233). This event is dated to about 3000 years BP at Paribari (Schrire 1982: 51). The abandonment of Malangerrangerr, Nawamoyn, Ngarradj Warde Jobkeng and Malakanunja II at the same time suggests local shifts in settlement and subsistence according to the increasingly mosaic environment on the floodplains during the Transition Phase (Hiscock 1999: 96).

According to Allen and Barton (1989: 93–94), the earliest secure date for the appearance of stone unipoints and bipoints in western Arnhem Land plains rockshelters is 4000 BP and they were not widespread in the region until after 3500 BP, although Jones & Johnson (1985a: 206) argue for an older date for their first appearance. The fact that these tools appear for the first time only in the upper levels of Nawamoyn and Malanangangerr supports the abandonment theory approx. 3000 BP. Stone unipoints and bipoints appear only in the lower levels of Paribari.

Surface mound (Kapalga N) on the lower South Alligator River coastal plains located above freshwater black soil (floodplain clay) contain *Nerita balteata*, which lives mangrove trunks, and *Certhidea* sp., found in the substrates of stands of the drier *Avicennia* and *Bruguiera*, suggesting exploitation of mangroves in the Transition Phase (Woodroffe *et al.* 1988: 96–97).

There is an increase in numbers of open sites toward the end of this period around 2000 BP. Earth mounds HD1 and MP2 on the Adelaide River floodplains contain increasing quantities of stone artefacts, fish bone and bone points that have been associated with multi-pronged spears for fishing (Brockwell 2005, 2009; Brockwell & Akerman 2007) (Fig. 7). Nearby is Scotch Creek I, an open site located next to a deep and permanent freshwater billabong

Fig. 7. Bone points from the Adelaide River. Photograph: Darren Boyd.

in open woodland two to three kilometres southeast of the main floodplains of the Adelaide River. In 1980, Smith (1981; Smith & Brockwell 1994) excavated a test pit and located cultural remains in a layer of black soil between 60 to 70 cm in depth above a clay substrate. A horizon of stone points located 10 to 15 cm above the clay substrate is dated to approx. 3000 BP and therefore to the Transition Phase (Smith & Brockwell 1994: 91; Smith 1995). On the basis of ethnographic association of stone points with light weight dueling spears, Smith (1995) speculates that the point horizon might represent a period of conflict associated with the changing and unpredictable nature of the resource base on the floodplains during this period. It is argued that the age of the site is no older than 4000 years as there are no mangrove shellfish present (Smith & Brockwell 1994: 93). The site has been occupied repeatedly since then (Crassweller 1996: 1). There are stone artefacts and faunal remains throughout the excavation (Smith & Brockwell 1994: 91). The animal taxa present include macropods, bird, freshwater turtles and fish (the only identified species being *Arius* sp.). The faunal analysis indicates that macropods (open woodland) are always a relatively more important taxon than at the main Adelaide River floodplain sites. Crassweller (1996: 78) concludes that the site was used as a base camp to exploit the billabong and open woodland and that manufacture and repair of stone artefacts took place there.

Hiscock (1999: 97) suggests that settlement may have shifted away from the escarpment and floodplains to the coast in this period, which was rapidly prograding and probably productive during the Transition Phase. This is supported by the increasing number of coastal sites. Sites dating from this period include Werat 14 in the west, which is located on a chenier ridge of the coastal plains of Reynolds River. It is dominated by the open beach species *Anadara granosa* (Guse 2005), as is MA1 in the Darwin region (Bourke 2000; 2005b). The shell mound Mari-Maramay 1 on Croker Island is dominated by *Gafrarium tumidum*, another open beach species (Mitchell 1994a: 281). Macassar Well shell mound at Milingimbi (McCarthy & Setzler 1960; Mulvaney 1975) and the shell mounds at Blue Mud Bay (BMB/29, BMB/82) are also dominated by *Anadara granosa* (Faulkner & Clarke 2004; Faulkner 2006: 189; Hiscock & Faulkner 2006; Faulkner 2008, 2009) (Fig. 9). In central Arnhem Land on the Blyth River, Maganbal midden dates to early in this period and is dominated by *Anadara granosa*. In eastern Arnhem Land, Gaynada midden on Cape Arnhem is dominated by *Marcia hiantina*, another open beach species (Bourke 2001). At Blue Mud Bay, BMB/018 is the oldest dated midden in the study area and is dominated by *Pinctada* sp. (pearl oyster) found in shallow water and *Melo* sp. (baler shell) found on sandflats or mudflats (Faulkner 2006: 112; 2008). BMB/033 and BMB/067 are dominated by species from shallow water and sandy mudflats (Faulkner 2006: 169). On Groote Eylandt, the base of Malmudinga midden is dominated by marine shells (Clarke 1994).

Sub-coastally, several shell middens are recorded on the lower South Alligator River, western Arnhem Land. Kapalga D is located on a salt mudflat surface and dominated by mangrove shellfish species *Terebralia palustris* and *Telescopium telescopium*. Palaeochannel middens (concentrated shell) Kapalga F and K are located on freshwater black soil (floodplain clay) and on the bank of a palaeochannel, respectively. Shell from Kapalga F was not collected but Kapalga K contains the mangrove species *Polymesoda erosa* and *Cerithidea* sp. (Woodroffe *et al.* 1988: 97). The mixed composition of the soil substrates and shell species and the concentrated location of sites suggest varying and mobile foraging strategies in response to the mosaic and dynamic nature of the floodplains during the Transition Phase.

On the other hand, the pattern of occupation in rockshelters on Vanderlin Island in the Edward Pellew islands follows a somewhat different trajectory. While (Wobuya Shelter) was reoccupied or occupied for the first

Fig. 8. Depiction of fish (Malarrak, western Arnhem Land). Photograph: Daryl Wesley.

time during this period (Worrungulumba, Babangi, Walala III, Victoria Bay III, Scissibar Creek, Boinmarnda), this was followed by a low intensity or abandonment phase of these sites between 2500 and 1700 years BP (Sim & Wallis 2008).

More complex and diverse rock art forms emerge towards the end of this period, including stick figures, abstract designs, beeswax figures and detailed X-ray art (Lewis 1988: 95; Taçon 1993: 114; Chippindale & Taçon 1998: 107). The X-ray art depicts a mixture of estuarine and freshwater species, especially fishes (Taçon 1987) (Fig. 8). It is argued that multi-pronged spears portrayed in the art are associated almost exclusively with fishing as a major economic activity on the floodplains during the Transition Phase (Brockwell & Akerman 2007). Some rock art complexes in western Arnhem Land contain scenes of large numbers of human figures and spears in a mêlée that suggests fighting, perhaps over changing resource availability, during this Transition Phase. Most of this change occurs in the latter half of this period and accelerates throughout the next period, after 2000 BP (Lewis 1988: 309; Taçon 1993: 114).

2000-500 BP. This period encompasses the early Freshwater Phase, when freshwater from the annual monsoons ponded behind cheniers and in palaeochannels. By 2000 BP this process had created the vast freshwater floodplains and wetlands that are a major feature of the northern coastal plains today (Chappell 1988; Woodroffe *et al.* 1988) (Fig. 4). With a continuing decline in effective precipitation, climatic variability increased in the region from approx. 1000 BP. There are dates from increasing numbers of sites including rockshelters (all but one located on the east coast), shell mounds, earth mounds and especially shell middens. The midden dates are predominantly from 1000 to 500 BP.

Allen and Barton (1989: 90–91) argue that the rockshelters of Malangangerr and Ngarradj Warde Jobkeng were reoccupied in this period after a period of abandonment of at least 2000 years. Although not dated, the upper levels of Paribari are dominated by freshwater fauna and flora that link the site firmly to the Freshwater Phase (Schrire 1982: 51–55, 58). Silica-polished adze flakes associated with experimental harvesting of *Eleocharis dulcis* (Akerman 1986), a reed that grows in freshwater swamps, are found in the upper levels of Paribari (Schrire 1982: 72). Polished flakes are also found in the upper levels at Nawamoyn (Schrire 1982: 137). There is a hint that Malakununja II continued to be occupied sporadically or was reoccupied in the Freshwater Phase, as freshwater mussel shell appears in the upper few spits (Kamminga & Allen 1973:45). Recent work on rockshelters in the Wellington Range in western Arnhem Land by Wesley and colleagues also indicates increased use of this environment after 1500 BP (May *et al.* 2010; Taçon *et al.* 2010). The resources of the wetlands and billabongs, coupled with a stable coastline, no doubt made these rockshelters desirable habitation sites, particularly during the wet season.

The inhabitants of Borngolo shelter in eastern Arnhem Land continued to exploit a similar range of marine, rocky shore, mudflats and open woodland species, as they did in the lower level of the site (see above). Schrire (1972: 666) notes that fish bones increase in the upper level, while mammal bones decrease, which she concludes represents a change in subsistence patterns with increasing sedentism

Figs 9–15. Archaeological sites mentioned in text: **9**, Blue Mud Bay. One metre high shell mound dominated by *Anadara granosa* located at Dilmitjpi on the Dhuruputjpi wetlands (Grindall Bay). Photograph: Pat Faulkner. **10**, Hope Inlet (HI81) Five metre high *Anadara* mound, part of large mound complex on laterite ridge overlooking saltflats. Photo Trish Bourke. **11**, Blyth River Gulukula shell mound. Photograph: Betty Meehan. **12**, Blue Mud Bay. Large *Anandara granosa* dominated shell mound positioned on the edge of a laterite ridge, Garangarri, Dhuruputjpi wetlands (Grindall Bay). Photograph: Pat Faulkner. **13**, Adelaide River. Earth mound MP5. Photograph: Sally Brockwell. **14**, Blyth River. Jibena earth mound. Photograph: Betty Meehan. **15**, Hope Inlet. Partially buried *Anadara granosa* midden looking seaward across salt flats. Photograph: Trish Bourke.

over time. Shell fish hooks also appear in the upper level only, about 1000 years ago. Schrire believes that this technology was a result of contact with South-east Asia. However, there is currently no conclusive archaeological evidence for contact between Aboriginal people with South-east Asia for this period. In the Edward Pellew islands, shell middens in rockshelters (Boinmarnda, Mushroom Rock, Komandarri-naboya, Turtle Shelter) accumulated steadily indicating more intensive occupation of Vanderlin Island during this period (Sim & Wallis 2008).

A large number of dates for shell mounds fall within this period. In the Darwin region, 21 shell mounds, dominated by the open mudflat species *Anadara granosa*, were located (Hiscock 1997; Bourke 2000; Hiscock & Hughes 2001; Bourke 2004, 2005b; Crassweller 2002, Bourke & Crassweller 2006; Crassweller 2006) (Fig. 10). Excavated shell mounds contain varying frequencies of stone artefacts and other faunal remains in addition to shell, mostly fish and crab with minor quantities of land animals and bird. Turtle is also identified in one mound (MA43) (Crassweller 2006: 20). In western Arnhem Land, two mounds, Field Island 3 and 4, are dominated by mangrove dwellers *Terebralia palustris* and the sandflat or mudflat species *Marcia hiantina* (Mowat 1995). One shell mound (V12 Vashon Head) on the Cobourg Peninsula is dominated by *Marcia hiantina* (Mitchell 1994a: 241). In central Arnhem Land, three shell mounds on the Blyth River, Gulukula (Fig. 11), Muyu-ajirrapa and Ngalijibama, are dominated by the open beach species *Dosinia* sp. Shell mounds from Milingimbi (Garki, Madanagum, Wallaby Mound (M96), Gadjaw 116) are dominated by *Anadara granosa* (Roberts 1991). In eastern Arnhem Land, there are seven shell mounds from Blue Mud Bay (BMB 36, 45, 52, 71, 92, 101, 116) (Faulkner & Clarke 2004; Faulkner 2006, 2008, 2009) (Fig. 12) and one (Barbara Cove Mound) from the Edward Pellew islands (Sim 2005; Sim & Wallis 2008).

After 2000 BP, earth mounds proliferated along the margins of newly formed freshwater wetlands (Brockwell 2006a). Further evidence of the trend towards established settlement behaviour on the Reynolds River is demonstrated by the prevalence of earth mounds in the region. Pandyal 2 and Djingurr 2 are today culturally significant to the Werat, especially the Djingurr mounds, which are near the central Dreaming place of the freshwater crocodile (Guse 2005: 114). Other earth mounds dated to this period include HI97 in the Darwin region (Bourke 2000: 225), MP2, MP5 and MP6 on the Adelaide River (Brockwell 2006a) (Fig. 13), Site 40 on the Mary River (Baker 1981: 62-63), and surface mounds Kapalga G and J in western Arnhem Land (Woodroffe *et al.* 1988: 97). In central Arnhem Land Ji-bena at the Blyth River contains freshwater turtle in its upper layers, indicating a shift to freshwater conditions of the adjacent swamp Balpilja (Brockwell *et al.* 2005: 86) (Fig. 14).

Numerous dates for shell middens fall within this period, predominantly from 1000 to 500 years BP. Middens in the Darwin region continue to be dominated by *Anadara granosa* (Bourke 2000) (Fig. 15). Middens in western Arnhem Land include those in the Alligator Rivers region (Kapalga C, L, M) dominated by mangrove species (Woodroffe *et al.* 1988: 97) and at Black Point, Port Bremer, Vashon Head and Stoneline 3 on the Cobourg Peninsula (Mitchell 1994a: 322). One pre-contact midden (Stoneline 3) contains *Lunella cinerea*, *Nerita chamaeleon* (rocky platform) and *Gafrarium tumidum* (sandy mudflats) (Mitchell 1994a: 321); one post-contact midden (Port Bremer 19) contains *Atactodea striata* and pottery (Mitchell 1994a: 224–225). In central Arnhem Land, this period is represented by Aningarra, Jilan-gajerra, Larrakun-ajirripa West and Muyu-ajirrapa on the Blyth River (Meehan 1982: 165–168), and Rulku and Balma 83 middens at Milingimbi (Roberts 1994: 178–179). Dates from eastern Arnhem Land, include Gaynada at Cape Arnhem (Bourke 2001), Blue Mud Bay – BMB/3, 17, 61, 67, 84 (Faulkner & Clarke 2004; Faulkner 2006, 2008, 2009), Groote Eylandt – Aburrkbumanja, Dirrangmurumanja and Malmudinga (Clarke 1994); and East Neck Saddle (ENII) on the Edward Pellew islands (Sim 2005; Sim & Wallis 2008).

Rock art in this period was prolific and significant (Taçon 1993: 113). Fully developed X-ray art, also called 'Freshwater', 'Later' or 'Decorative X-ray', coincides with the arrival of freshwater conditions on the floodplains. It features specific and precise representation of inner organs and is the dominant form in western Arnhem Land and exhibits much more regional variation at this time (Chaloupka 1985; Taçon 1987; Lewis 1988: 55, 99–102; Chaloupka 1993: 114; Taçon 1993) (Fig. 16). Throughout this period, the art becomes increasingly elaborate and decorated and the internal features became more abstract (Chaloupka 1985: 277; Taçon 1987; Lewis 1988: 99; Taçon 1993). It depicts freshwater fauna and flora, such as magpie geese (*Anseranus semipalmata*) and lotus lilies (*Nelumbo nucifera*); and new technology, such as large stone blades 'leiliras', 'goose' spears and spear throwers (Chaloupka 1985: 277–278; Lewis 1988: 55, 101–102). It should be noted that 'goose' spears were not used for spearing geese – but rather were lightweight spears used with a 'goose' spearthrower – so-called because the wax hook made it look like a goose head (Lewis 1988: 384; Allen 2011: 78). These spears appear to have been used for dueling. Guse & Woolfe (2006) further demonstrate that the occupation of the coastal plains in western Arnhem Land is reflected by rock art that expanded from gorges and shelters in the escarpment to the outliers with the progression of floodplain evolution. Analysis of the spatial and temporal distribution of these sites indicates a late Holocene reorganisation of land use strategies, social economies and group interactions for the plateau and plains. Guse & Woolfe (2006) conclude that late Holocene changes in the rock art sequence reflect a growing confidence to occupy openly accessible sites in terms of social ecological stability and security, related to ecological abundance and diversity following sea level

Fig. 16. Depiction of barramundi (Malarrak, western Arnhem Land). Photograph: Daryl Wesley.

stabilisation. The art of this period displays great diversity and regionalisation (Taçon 1993).

Post 500 BP. This period encompasses the later Freshwater Phase and the Contact Period. The Contact Period can be separated roughly into two overlapping phases, the South-east Asian period from at least the 1660s (probably older) through to the early 1900s, and the European contact period beginning in the early 1800s (Macknight 1976; Mitchell 1994a: 56; Clarke 2000; Clarke & Frederick 2008; May *et al.* 2010; Taçon *et al.* 2010; Wesley 2011). The latter part of this period was dominated by environmental changes brought about by European contact, with impacts from feral animal and exotic weed species adversely affecting productivity, especially of the floodplains (Petty *et al.* 2007; Bradshaw 2008; Walden & Gardener 2008). Dates come from rockshelters, fewer shell mounds and earth mounds, and an increasing number of shell middens.

Macassans, Bugis and others from South Sulawesi and nearby islands established a trade in trepang (bêche de mer), which they obtained and processed on annual visits to northern Australia and sold onto the Chinese who regarded it as a tonic and aphrodisiac. The Southeast Asians supplied the Aborigines with trade goods such as metal, tobacco, beads and cloth in return for access to their lands and other benefits (Macknight 1976; Mitchell 1994: 181). The exact beginnings of this trade are uncertain and debatable (see Discussion below).

Two rockshelters from western Arnhem Land, Malakanunja II and Malangangerr, date to this period. Allen & Barton (1989: 90–91) interpret this as reoccupation following a long period of abandonment of 2500 years. In eastern Arnhem Land at Borngolo shelter, plant remains in the uppermost levels indicate that the inhabitants continued exploiting the sea shore, monsoon forests, and open woodland, with a range of implements including stone points, scrapers, hammers (Schrire 1972: 662–663). Schrire (1972) concludes that the deposit at Borngolo represents pre and post-contact Aboriginal subsistence behaviour. She interprets more intensive occupation in the upper levels as being the desire of the Aborigines to be in close contact with the Macassans for trade benefits. On Groote Eylandt, five rockshelters (Angwurrkburna, Dadirringka, Lerrumungumanja, Marngkala Cave, Mungwujirra) belong to this period.

There are only four shell mounds recorded. One mound from the lower South Alligator River floodplains (Kapalga B) includes open beach species (Woodroffe *et al.* 1988: 97). The others are in central Arnhem Land on the Blyth River (Ngalijibama, Yuluk-adjirrapa), both dominated by open beach species, *Mactra* sp. and *Dosinia* sp., and Blue Mud Bay in eastern Arnhem land (BMB 116) dominated by another open beach species (*Anadara antiquata*) (Faulkner & Clarke 2004; Faulkner 2006, 2008, 2009).

There are dates from seven earth mounds in this period. In the west, Djingurr 1 is located on the Reynolds River. In the Darwin region on the Adelaide River, a modern date was obtained from NP20, which also contains contact material (Brockwell 2005: 11). On the Mary River, Site 38 is also dated as modern. In western Arnhem Land, the deposit at Kina adjacent to the freshwater wetlands on the South Alligator River floodplains is dominated by the freshwater mussel *Velesunio angasi* and polished flakes, similar to those found in the upper levels of Paribari (Meehan *et al.* 1985: 150). Kina is associated with a large open

Fig. 17. Blyth River. Guna-jengga midden. Photograph: Betty Meehan.

Fig. 18. Vanderlin Island midden. Photograph: Robin Sim.

artefact concentration, one of many lining the floodplain margins of the South Alligator River (Meehan *et al.* 1985; Brockwell 1996). These sites contain hundreds of thousands artefacts, including polished flakes and trigonal or 'leilira' blades, which are also commonly found in upper levels of rockshelter sites dated to the last 1000 years in outliers of the Arnhem Land escarpment (Jones & Johnson 1985b: 208). Hiscock (1999: 99–100) speculates that there may have been a shift inland from the coast to the freshwater wetlands following the cessation of shell mound building approx. 500 years BP. Supporting this theory is intensified occupation at the Adelaide River earth mounds dating to less than 600 years BP (Brockwell 2009).

Most of the middens recorded belong to this period. In the Darwin region, two shell concentrations, MA52b and WIN10, are dominated by mangrove species *Telescopium telescopium* (Bourke 2005a) suggesting that the Darwin mudflats were being recolonised by mangroves at this time. In western Arnhem Land, on the floodplains of the lower South Alligator River, seven middens (Kapalga A, B, E, L, M1, M2), contain a mixture of mainly mangrove species (Woodroffe *et al.* 1988: 97). On Cobourg Peninsula, Site V1 at Vashon Head is dominated by *Atactodea striata* and *Marcia hiantina*, both sand and mudflat bivalve species. On the basis of site content, Mitchell defines 17 sites as belonging to pre-Macassan contact (pre 1720 AD) and 12 post-contact midden sites. He concludes that the post-contact midden sites were substantially larger than the pre-contact sites and contain a wider variety of exotic artefacts and remains of large marine fauna (1994a: 377–398).

In central Arnhem Land, there are three middens from the Blyth River (Aningarra, Guna-jengga, Jilan-gajerra) (Meehan 1982: 165–168; Brockwell *et al.* 2009) (Fig. 17). In eastern Arnhem Land, there are four middens at Blue Mud Bay. BMB 16 and 84 are dominated by open beach species, while BMB 15 contains mangrove shellfish and BMB 22 contains rocky coast species (Faulkner & Clarke 2004; Faulkner 2006, 2008). On Groote Eylandt, the 11 middens from this period are dominated by marine shell (Clarke 1994). On the Edward Pellew islands, five surface shell scatters (Investigator Bay, Vanderlin Creek 2, Wabuya Creek, Walala Dunes, Kedge Point) date from this period and through to the Contact Period (Sim & Wallis 2008) (Fig. 18). Sim & Wallis (2008: 103) report that there is no direct evidence of Maccassan contact in the Edward Pellew islands archaeology, despite the well-known historical presence of trepanging in the region, as well as the linguistic and rock art record and use of dug out canoes that show contact. Nor is there evidence of intensified occupation of archaeological sites associated with Macassan presence and trade goods, as is argued for the Groote Eylandt, Borngolo Shelter and the Cobourg Peninsula (cf Schrire 1972; Mitchell 1995, 1996; Clarke 2000). However, Sim & Wallis (2008: 103) suggest that the marked decline in the manufacture and use of stone artefacts post 500 years BP may be evidence of replacement with metal tools brought by Macassans.

Aboriginal rock art traditions continue through this phase of occupation. The Contact Period is recorded through images of South-east Asian perahus and items of material culture, and European ships, guns and introduced animals such as horses and buffaloes (Chaloupka 1985: 278; Chaloupka 1996; Chippindale & Taçon 1998; Clarke & Frederick 2006; May *et al.* 2010; Taçon *et al.* 2010; Clarke

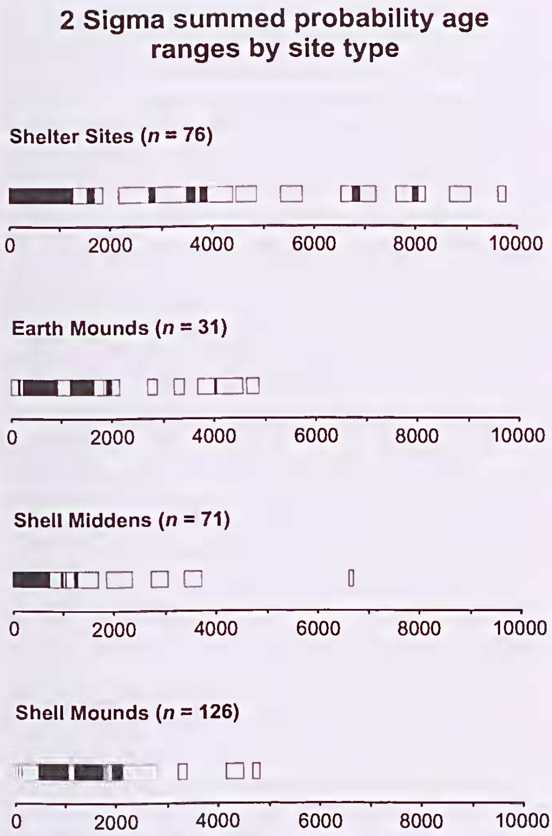

Fig. 19. C14 graphs by site type.

& Frederick 2011; Wesley in press). This is also the case for the art from Groote Eylandt (Clarke 1994, 2000a, 2000b) and Edward Pellew islands (Sim 2002).

In summary, there are four main site types that occur on the coastal plains; rockshelters, shell mounds, earth mounds and shell middens. Rockshelters are the oldest site type and date from the early Holocene period. They are located on the Reynolds River in the west of the Northern Territory, western Arnhem Land and the Edward Pellew islands in eastern Arnhem Land (Fig. 19). Such sites are located on the edge of the coastal plains and were generally occupied throughout the Holocene. The exceptions are islands such as Groote Eylandt, where occupation falls largely within the last 500 years, and the Edward Pellew islands, where the evidence indicates an occupational hiatus between about 6700 and 4200 BP, following sea level rise and the cut off of the islands from the mainland.

Shell mounds occur right across the Top End. There are a few 4000–4500 year old examples from Reynolds River and western Arnhem Land, but the majority fall between 2500 and 500 BP (Fig. 19). They are usually dominated by shell species from open beach habitats.

Earth mounds tend to occur at the junction of a number of resource zones close to the coast, or inland on black soil plains that contain extensive freshwater wetlands systems bordering open woodland. Apart from a few older examples from the Reynolds and Adelaide rivers and Kakadu, the majority of earth mounds are less than 2000 years old.

Shell middens occur along the coast and adjacent to palaeochannels on the floodplains of major rivers across the Top End. They are mostly less than 2000 years old, with the majority being less than 1000 years old (Fig. 19). The older exceptions are in western Arnhem Land, where middens are found buried on the South Alligator River floodplains, and one site in central Arnhem Land, on the Blyth River.

DISCUSSION

We argue that regional variation in chronology and site distribution is due largely to local topography, and the timing and nature of landscape formation. The evidence for earlier Holocene occupation of these landscapes comes from rockshelters that only occur in some areas where the escarpment is adjacent to the coastal plains. There does appear to be some preservational bias in the record, and it is obvious that it plays a role in site distribution. For example, rockshelters are effective information traps preserving older chronostratigraphic sequences. Early Holocene open sites are rare as unless they are rapidly buried they do not preserve organics. Buried open sites are rarely located and sampled. There is also a geographic bias in our current site sample. Across the broader region, the east coast is the best dated with 134 dates, and the western region, represented by the Reynolds River, the least well-dated with only eight dates. This discrepancy has the potential to skew the data, particularly when combined with a research focus on open sites in a number of regions, making interpretation of settlement patterns through time difficult.

That said, however, and given the preliminary nature of the analysis, several interesting patterns begin to emerge. We can see variability in the timing and nature of occupation relative to the geomorphic and climatic parameters outlined. This is particularly evident when considering the differential occurrence of open sites. The pattern of settlement on the coastal plains of the Northern Territory prior to South-east Asian contact, more or less tracks the evolution of the landscape and changing opportunities in terms of the creation of new resource zones. With rising seas, evidence of occupation 10,000 years ago was confined mainly to rockshelters on the margins of the coastal plains. Groote Eylandt and the Edward Pellew islands were cut off from the mainland by rising seas approx. 7000 years ago. Shortly after the spread of the mangroves in the Big Swamp Phase, people began foraging along the edges of the vast swamps of the northern floodplains from 7000 BP and the rockshelters adjacent were occupied more intensively. With increasing sedimentation the mangroves declined and after 4000 BP people began to move out onto the floodplains and the rapidly prograding coastline, witnessed by the increasing number of open sites in this period. People also began to travel offshore, reinhabiting the Edward Pellew islands approx. 4000 years ago. Between 4000 and 2000 BP, there was a diversity of fresh and estuarine environments being exploited on the floodplains, reflected in the faunal assemblages from rockshelters and open sites. Following the Big Swamp Phase, the combination of sea-level recession, continued sedimentation in former shallow embayments built out intertidal mudflats suitable for shellfish biomass. This saw the proliferation of shell mounds in a number of regions across the Territory between approx. 3000 to 500 BP. Figure 2 shows the chronology of shell mounds relative to the environmental data. From 2000 BP, freshwater conditions were established on the sub-coastal plains and earth mounds and artefact concentrations proliferated along the floodplain margins. Between 800 and 500 years BP, environmental change in shoreline characteristics and climatic variability associated with ENSO activity led to a decline of sandy/mudflat shell beds and shell mounding behaviour all but ceased in the Northern Territory (Bourke *et al.* 2007). Subsequently, mangrove-lined beaches and coastal wetlands were established, economies diversified and middens became more common with molluscs harvested from varied habitats after 500 years BP. There is some suggestion that there may have been some relocation from the coast to the seasonally abundant sub-coastal freshwater wetlands during this period (Hiscock 1999).

There are debates about the socio-cultural implications of the archaeological record. Some authors (e.g. Bourke 2005b), quoting the ethnographic literature, have associated mound-building behaviour between approx. 3000 to 500 BP with ceremonial activities and territorial demarcation. Contrary to this, Hiscock and Faulkner argue that there is no historical analogue for shell mounding and the social and economic systems that produced them no longer exist. They hypothesise that the diverse mythology recorded ethnographically that surrounds shell mounds is a recent construction to explain the existence of alien landscape features within modern foraging and social practices (Hiscock & Faulkner 2006: 218).

In the sites under discussion, stone unipoints and bipoints appear to be concentrated in a narrow horizon dating from 4000 BP and are rare in the upper levels less than 2000 years old. Stone points are frequently recorded in surface artefact concentrations from the northern coastal plains and although undated may be from this period. The appearance of stone points is part of a widespread technological change across the Top End in the mid Holocene. It is widely agreed to be dated from at least 5000 until 1500 years BP (Allen & Barton 1989: 94-95; Hiscock 1999: 98; Clarkson 2006b: 165–166; Smith & Brockwell 1994: 101). Hiscock (1999: 98) argues that points appear as early as 7000 BP coinciding with the Big Swamp Phase and that mid Holocene changes in stone technology were driven by changes in resource availability created by the evolution of the coastal plains. He goes on to say that unipoints and bipoints are part of a continuum of manufacture, and represent a risk strategy in times of uncertainty (Hiscock 1994a, 1994b, 1999: 98). Clarkson (2006a: 105, 2006b: 165–166) agrees with this analysis and argues that regional technological change was a response to environmental variability created by the onset of ENSO (El Niño Southern Oscillation) from 5000–2000 years ago. Smith & Brockwell (1994: 102) argue that concentrated manufacture of stone unipoints and bipoints at Scotch Creek between 3800 and 2100 cal. BP coincides with the Transition Phase, a period of environmental stress when increasing aridity and the changing nature of the floodplains made resources unpredictable. Smith (1995) associates stone points with spear tips and suggests that tensions over access to resources and inter-group conflict led either directly to warfare or threatening displays at ceremonies. Certainly depictions of inter-group fighting in western Arnhem Land rock art became more common in this period (Taçon & Chippindale 1994). However, a phytolith study conducted to investigate environmental change was unable to firmly establish the connection between changes in climate and changes in archaeology (Clarkson & Wallis 2003). It might be noted that there are no ethnographic examples of spears hafted with small unifacial or bifacial points known from the northern coastal areas, though they do occur in the Kimberley region.

It is suggested that South-east Asian contact may have occurred from perhaps as long ago as 800 years BP (Clarke 2000b: 325–328; Clarke & Frederick 2011:151). Macknight (1976, 1986) and Mitchell (1994: 56) argue that it more likely dates from the 1720s when there is documentary evidence for the Macassan trade in trepang with the Chinese. However, recent dating has shown that the image of a Macassan perahu on the walls of a rockshelter in western Arnhem Land has a minimum age of 1664 and may be as old as 1517 AD (Taçon *et al.* 2010). Whatever the timing, these visits had a profound impact on Aboriginal social and economic organisation on the northern coastal plains (Clarke 2000b). In eastern Arnhem Land, Schrire (1972) posits that the people of Port Bradshaw replaced traditional stone and bone tools with metal artefacts and became increasingly sedentary as a result of contact with Macassans. Mitchell (1994a, 1994b, 1996) argues persuasively that the economy and settlement patterns of Cobourg Peninsula in western Arnhem Land were completely reorganised and local populations were able to rely much more on exploitation of large marine animals as a result of the adoption of the dugout canoe and access to metal to manufacture harpoons. Metal axes also allowed Aborigines to exploit the hard dupes of *Pandanus*, which contain an energy-rich kernel (Meehan *et al.* 1979). These new technologies allowed groups to extend their hunting range and access previously under-utilised resources (Faulkner 2006: 6). It is argued that contact with Macassans stimulated ceremonial exchange cycles and trade networks, involving a variety of objects including stone, shell, metal, spears, cloth, baskets, nets etc, that extended from eastern Arnhem Land into western and southern Arnhem Land and beyond (Allen 1996a, 1997;

Berndt 1951; Davidson 1935; Evans & Jones 1997; Jones & White 1988; Mitchell 1994b, 1996; Paton 1994; Thomson 1949). This network included trade in large stone blades manufactured at Ngilipitji quarry in north-eastern Arnhem Land (Jones & White 1988). Production of similar artefacts, manufactured in the quarries of western Arnhem Land (Jones & Johnson 1985a: 188) and found in the rockshelters and open sites restricted to the last 1000 years, may also have been stimulated by this Arnhem Land wide phenomenon.

From 180 years ago, Europeans and later Chinese began penetrating the coastal plains of the Northern Territory. The earliest incursions were British settlements on Bathurst and Melville Islands and on Cobourg Peninsula (Allen 1980; Keen 1980; Mitchell 2005). Apart from the devastating impact of introduced diseases which greatly reduced the Aboriginal population, one effect of these early settlements was the spread of feral buffaloes throughout the coastal plains, especially between Darwin and western Arnhem Land, where they wreaked havoc on the freshwater wetlands. Apart from the damage to wetlands resources, Meehan (1991: 203–205) points out that as Aboriginal people feared buffaloes, this also had the effect of altering their hunting and foraging patterns on the coastal plains in general. In 1858, South Australia annexed the Northern Territory and there was a brief settlement at Cape Hotham near the mouth of the Adelaide River, which subsequently moved to Port Darwin. These initial settlements were followed by pastoralists, buffalo shooters, miners, timber getters, pearlers, fishermen and missionaries. European and Chinese presence had profound effects on Aboriginal social and economic systems and settlement patterns, some of which are reflected in the archaeological record. For example, on Groote Eylandt, as people became more settled on the missions they became more reliant on European food supplies. When they did forage, they targeted easily accessible and favourite bush foods (Clarke 2011). Consequently, midden sites examined on Groote Eylandt relating to this period consist of a limited number of taxa, all of which were available in the immediate environment. As a result of this process, these sites are seen to conform to the criteria outlined by Meehan (1988) for 'dinner-time' or temporary camps (Clarke 1994: 458). People are presumed to have operated a dual subsistence system – one that had a commodity-based component involving the consumption of European resources, and a hunter-gatherer lifestyle that integrated traditional practice with elements of the new (Clarke 1994: 462). As indicated previously, however, many of these traditional practices arose during the period of contact with Macassans (Faulkner 2006: 8). A similar situation existed on the Adelaide River, where earth mounds from the Contact Period were dominated by estuarine shellfish, as the resources of the freshwater wetlands were impacted negatively by the incursions of feral animals and exotic weeds (Brockwell 2005: 15-16).

CONCLUSION

The above synthesis is a preliminary attempt to integrate the archaeological evidence within an environmental framework. With only a few exceptions, environmental and archaeological research on the coastal plains of the Northern Territory was not undertaken in tandem. This means that research questions often had different foci and the data sets do not necessarily intersect. We hope that future research is more inter-disciplinary in nature. In this way multiple lines of evidence can be used to reconstruct both the natural and cultural landscape and aid in interpretation of the interactions between the two.

Although extensive geomorphological work has been done, there has been little palaeo-climatic research in this region of northern Australia. We envisage that future research programs would explicitly address questions of climatic variability and its impact on human settlement and mobility. Such research would be dedicated to investigating regional and local patterns through isotope analysis and coral proxies. This research could also be integrated with palaeoecological investigations through analysis of pollen, diatoms and phytoliths from both existing archaeological soil samples and coring programs into the many suitable swamps of the Northern Territory. Due to the comparative paucity of work to date in the western region of the Northern Territory, we see this area as a priority area for future research.

The archaeological record demonstrates that the last 10,000 years have witnessed recurrent economic and social reorganisation for the occupants of the coastal plains of the Northern Territory. We argue that the evidence clearly suggests this is a result of variable climatic and environmental conditions and landscape evolution combined with contact with peoples from South-east Asia [and later Europeans] within at least the last 400 years. This may seem to be an overly deterministic point of view, but is not unlike the conclusions from other archaeological studies in the coastal areas of northern Australia. They have implied that major environmental changes, rather than strictly social changes, preceded growth in human populations, and that the growing productivity of newly created landscapes combined with higher population levels, were causal factors in cultural change, variations in mobility, and increasing land and sea use during the Holocene (cf. Beaton 1985; Jones 1985b: 291–293; Meehan *et al.* 1985:153; Sullivan 1996: 7). In explaining the variability of coastal occupation in the north over the Holocene, a number of researchers have focused on environmental explanations such as changes in local ecological habitats (e.g. Hiscock 1999; Hiscock & Mowat 1993; Mowat 1995; O'Connor 1999), as well as pointing to the links between the appearance of mounds and evidence for increasing aridity and the northward movement of the northern monsoon on the coast (O'Connor & Sullivan 1994; O'Connor 1999). This particular type of ecological perspective does not view human culture as being determined by the environment, nor does it assume perfect adaptation of humans to their environment. Rather, it suggests that the archaeological manifestation of a defined set of human behaviours, such as the structure of economic activity, may best be viewed in terms of the formation of a particular environment (Allen 1996b; Cribb 1996:150; Faulkner 2006: 18).

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